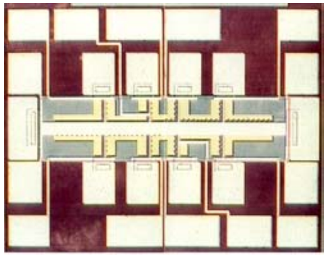
Phase transition in a strongly correlated 2D electron system

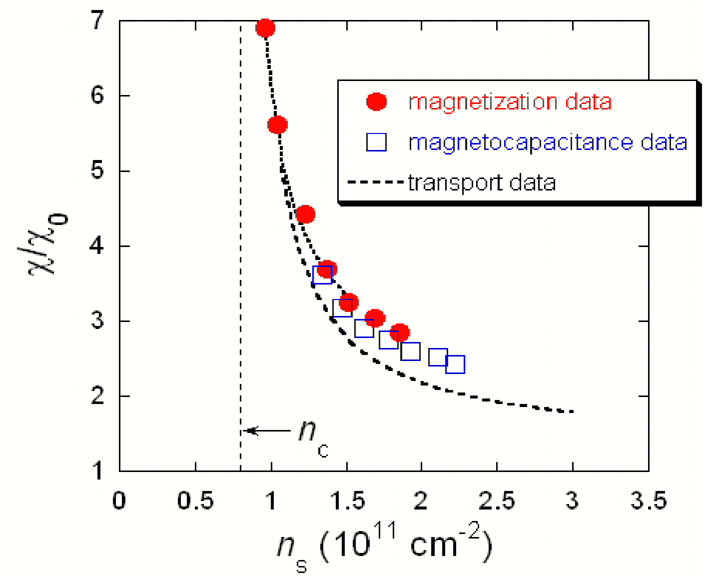
S. V. Kravchenko, Northeastern University, DMR-0403026

One of the outstanding problems in modern condensed matter physics is the behavior of strongly correlated electrons. Development of the next generation of semiconductor devices for high-speed communications, signal processing, imaging, detection, and especially semiconductor-based quantum computation and spintronics depend heavily on this kind of knowledge. Here we present *thermodynamic* measurements of the spin susceptibility in a clean strongly-correlated electron system in silicon transistors. It is found that the spin susceptibility becomes enhanced by almost an order of magnitude, diverging close to the metal-insulator transition. This gives thermodynamic evidence for the existence of a phase transition in strongly 2D correlated electron systems.

Science, submitted (2004).



Silicon metal-oxide-semiconductor field-effect transistor used for measurements of the spin susceptibility.



Diverging spin susceptibility near the metal-insulator transition (marked as n_c).

Phase transitions are often related to a change in the kinetic properties of electron systems. Recent transport experiments performed on the clean two-dimensional electron system in silicon suggest that this system possesses anomalous magnetic properties at low densities of electrons [1]. On the other hand, evidence for a phase transition cannot be conclusively based on results obtained by transport experiments: it must be sought in studies of the thermodynamic characteristics. Recently, we have performed *thermodynamic* measurements of the spin susceptibility and density of states in a low-disordered, strongly correlated two-dimensional electron system in silicon. Both methods yield the in-plane magnetic field at which the electrons' spins become fully polarized. We have found that the polarization field changes linearly with electron density and tends to zero close to the critical density for the metal-insulator transition. The spin susceptibility of the electrons becomes enhanced by almost an order of magnitude with a tendency to diverge near the transition. This gives thermodynamic evidence for the existence of a long-sought phase transition. The paper was submitted to *Science* a week ago.

[1] S. V. Kravchenko and M. P. Sarachik, *Rep. Prog. Phys*. **67**, 1 (2004)

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Education:

Three graduate students (Mohammed Sakr, Svetlana Anissimova, and Venkatesan Ananth) contributed to this work. Mohammed Sakr received his Ph.D. in 2003 and is presently a postdoc working for H.-W. Jiang in the Department of Physics and Astronomy at UCLA. Svetlana Anissimova and Venkatesan Ananth are still members of the PIs group and are performing related experiments.

Societal Impact:

The ability to measure magnetic properties such as spin susceptibility of strongly correlated electrons is a new and very powerful technique, which may lead to the development of new kinds of electronic and spin devices, including semiconductor-based quantum computers.